DOCUMENT RESUME

ED 475 486 SE 067 774

AUTHOR	Klemm, E. Barbara; Iding, Marie K.; Crosby, Martha E.
TITLE	Cognitive Load Criteria for Critical Evaluation and Selection of Web-Based Resources for Science Teaching.
PUB DATE	2003-03-23
NOTE	9p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Philadelphia, PA, March 23-26, 2003).
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	*Computer Uses in Education; Elementary Secondary Education; Evaluation; Evaluation Criteria; Inquiry; *Instructional Materials; *Preservice Teachers; *Science Instruction; Teaching Methods; *World Wide Web

ABSTRACT

This study addresses the need to develop research-based criteria for science teacher educators to use in preparing teachers to critically evaluate and select web-based resources for their students' use. The study focuses on the cognitive load imposed on the learner for tasks required in using text, illustrations, and other features of multi- media, hyper-linked web-resources. This study seeks to use terminology that is meaningful and clear to teachers to develop criteria for the evaluation of the learners' cognitive load in the use of web sites. These criteria will be useful for science teacher educators to prepare teachers to critically evaluate web resources. Drawing from prior research, this study formulates ways to assess the cognitive load of instructional plans available on the web. Preservice teachers in an elementary and secondary science methods class were asked to use the criteria to assess pre-selected science WebQuests, a type of teacher- male inquiry instruction compatible with science process learning and the learning cycle. Results from individual preservice teacher's ratings using the criteria, and from follow-up in-class discussions are presented and used to identify criteria understood and found useful to elementary and secondary preservice teachers, and those criteria needing further refinement. (Author)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 475 486

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

E.B. Klemm

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

1

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Cognitive Load Criteria for Critical Evaluation and Selection of Web-Based Resources for Science Teaching

Paper presented at the annual meeting of the
National Association for Research in Science Teaching,
Philadelphia, PA March 23-26, 2003

E. Barbara Klemm, Professor
Dept. Teacher Education & Curriculum Studies
College of Education, University of Hawaii
Contact: klemm@hawaii.edu

Marie K. Iding, Associate Professor
Dept. Educational Psychology
College of Education, University of Hawaii

Martha E. Crosby, Professor
Dept. Information & Computer Science, University of Hawaii

SE067774

BEST COPY AVAILABLE

Abstract

This study addresses the need to develop research-based criteria for science teacher educators to use in preparing teachers to critically evaluate and select web-based resources for their students' use. The study focuses on the cognitive load imposed on the learner for tasks required in using text, illustrations, and other features of multi-media, hyper-linked web-resources. We seek to use terminology that is meaningful and clear to teachers to develop criteria for the evaluation of the learners' cognitive load in the use of web sites. These criteria will be useful for science teacher educators to prepare teachers to critically evaluate web resources. Drawing from their prior research, the authors formulate ways to assess the cognitive load of instructional plans available on the web. Preservice teachers in an elementary and a secondary science methods class were asked to use the criteria to assess pre-selected science WebQuests, a type of teacher-made inquiry instruction compatible with science process learning and the learning cycle. Results from individual preservice teacher's ratings using the criteria, and from follow-up in-class discussions are presented and used to identify criteria understood and found useful to elementary and secondary preservice teachers, and those criteria needing further refinement.

Subject/Problem

This study addresses the need to develop research-based criteria for science teacher educators to use in preparing teachers to critically evaluate the appropriateness of web-based science resources for their elementary, middle school, and high school learners. In earlier research, we compared teachers' and scientists' perceptions of the credibility of printed and electronic information sources. As we had expected, scientists were more critical about many of the information sources than were teachers, especially elementary teachers. We also found interesting differences between elementary and secondary teachers, suggesting in part, that teachers' views are shaped by the developmental needs of the students that they teach (Klemm, Iding & Speitel, 2001).

We then worked with high school biology students to have them develop their own criteria for critically evaluating websites generally and the scientific information in them specifically. The students were oriented to basic website terminology and given three general areas of website evaluation to consider: validity, credibility, and presentation (based on work from Farah, 1995; Rader, 1998; and adapted by Nguyen, 2000). The students indicated the process of learning to critically evaluate website as most valuable to them, and they generated more extensive lists of criteria than generated at the outset of the intervention (Iding, Landsman & Nguyen, in press). In other research, we compared self-ratings of preservice educational psychology students with those of computer science students on two aspects of critical evaluation of websites. Interestingly, the education students rated themselves lower than the computer science students on evaluating websites, but higher than the computer science in competence on evaluating course-related topics (Iding, Crosby, Auernheimer & Klemm, 2002). Pertinent to the present research, these findings suggested to us the need to further examine teachers' views in critically evaluating websites.

In another study (Iding & Klemm, 2002), we examined teachers' determinations of appropriate cognitive load associated with websites and other multimedia material. We defined cognitive load in accord with Chandler and Sweller (1991) and Sweller and Chander (1994), referring to the extent to which cognitive resources are taken up by tasks that are either relevant to or unrelated to learning. For example, "split attention effects" occur when learners must coordinate separate text and illustrations (Sweller & Chandler, 1994). Kischner (2002), Bannert (2002), and Valcke (2002) further differentiate types of cognitive load. Specifically, we were interested in how preservice teachers conceptualized the notion of cognitive load in critiquing and selecting web-based materials for their students, which they were free to select. When asked to develop their own criteria for assessing cognitive load as an aspect of selecting a web site for their students to use, teachers included "developmentally/cognitively appropriate" most often, then information load, and also criteria pertaining to "visual density" (too much/not enough visuals). Among our findings was the need to develop consensus among

educators as to the criteria, and the terms or language used in them, together with examples for the students.

Iding (2000) reviewed some of the relevant effects emerging from this line of research and related research that would be relevant to development of criteria. In that article, she summarized research as follows:

> "Some aspects of textual and multimedia design that can reduce cognitive load on learners include: Presenting smaller, more manageable chunks of texts-with-illustrations (Mayer, 1999); Presenting illustrations and relevant texts in proximity to minimize the visual search process (Chandler & Sweller, 1991; Sweller & Chandler, 1994); Minimizing extraneous information or sensory input (Mayer, 1999); and Using auditory input to accompany diagrams, to minimize excessive resources that may be spent in visual search or construction of visual representation while at the same time reading accompanying text (a second and possibly competing visual process) (Mayer, 1999)" (p. 410).

Design/Procedure

The present study builds on our previous work, this time looking at the cognitive load factors used by in critically evaluating websites for their students' use in preselected web-based inquiry lessons. Participants were preservice enrolled in an elementary science (N=21) or secondary science (N=19) methods course. Participation was voluntary and anonymous, and took place during 2 class sessions.

For this study, we used an existing web-based inquiry instructional model, the WebQuest, as a vehicle to support our research on what teachers need to learn and be able to do in order to critically evaluate and select websites for their students to use. A WebQuest is "an inquiry oriented activity in which most or all of the information used by learners is drawn from the Web" with the focus on using information, not searching for it. According to WebQuest developers Dodge and March (1995), WebQuests support learners' thinking at the levels of analysis, synthesis, and evaluation (http://webquest.sdsu.edu/overview.htm). A WebQuest is an example of an assigned search of web site links. Each WebQuest contains a resource list of web sites that were selected as appropriate and relevant by the teacher(s) who developed the lesson. Moreover, the WebQuest site provides an introductory lesson orienting teachers to the model, called A WebQuest About WebQuests, with elementary and middle school/high school versions available at the WebQuest home page (http://edweb.sdsu.edu/webquest/webquest.html.)

We modified the introductory WebQuest lesson worksheet. First, we changed the web resource list so that it contained only science web sites, rather than a sampling of different subject areas. Importantly, for this study, we included one science website in common for both the preservice groups. Second, we added to the introductory worksheet. brief instruction about website evaluation and cognitive load, plus criteria derived from the recommendations of Iding (2000) and other prior research (discussed earlier). We asked participants to use these criteria to critically evaluate each web site.

Otherwise, we followed the introductory lesson strategy in the A WebQuest About WebQuests.

The elementary or middle school/high school preservice teachers were assigned specific WebQuest science lessons to examine. Participants recorded responses to each worksheet/questionnaire item as they performed their assigned tasks. Working in groups of four, each took on one of the following assigned roles: efficiency expert (examining use of time); affiliator (need for collaboration, discussion and consensus); atitudinist (examining higher order thinking) or technophile (making the best use of technology). Working individually, participants spent about 10 minutes to examine each of the sites from the assigned perspective, and to record observations, in keeping with the original worksheet. Unlike the original worksheet, we also asked each participant to critically evaluate each web site using the criteria we provided. We asked them to evaluate cognitive load associated with the web sites using criteria derived from previous researchm for example, Iding & Klemm (2002), derived from Farah, (1995 and Rader (1998), and adapted in the work of Nguyen (2000), and Iding, Landsman and Nguyen (2001), also Iding & Klemm (2002) adapted from Changler & Sweller, 1991 and Sweller & Chandler (1994). Then, group members conferred to discuss their individual ratings of web sites using our modified worksheet, which emphasized cognitive load criteria. They recorded notes during their discussion which aimed at developing a compromise consensus in ranking the web sites. As with the original introductory worksheet, we did not expect them to reach unanimous agreement. One person from each group then reported the group's thoughts to the class.

Data Analysis and Findings

We first ascertained the expertise levels with respect to using web sites. More elementary teachers rated themselves as novices with respect to searching for materials on the web, selecting materials for their own use as students, selecting materials for their use as a teacher, and selecting materials for their students to use (i..e., elementary teachers selected the novice category 33 times, whereas secondary teachers selected it 20 times.) Secondary teachers rated selected the category "expert, could teach others" more often (6 times) than did elementary teachers, who selected this category only twice. The vast majority of responses from both groups indicated that they consider themselves as proficient (selected 44 times for secondary teachers and 46 times for elementary teachers.)

Students were asked to rate each portion of one selected, common WebQuest site in terms of information density (1 = too little, 2 = about right amount, 3 = too much) and complexity in navigation (1 = easy, 2 = about right, 3 = difficult). Frequencies were tabulated in each category. Preliminary examination of the results indicated that the largest differences between elementary and secondary teachers' views of information density of the web site were in their ratings of the amount of visual information ($\underline{m}$=1.1 for elementary and $\underline{m}$= 1.79 for secondary) and textual information ($\underline{m}$ = 2.76 for elementary and 2.26 for secondary teachers). This indicates that elementary teachers

tended to rate the overall information for the particular web site as more dense and the textual information as more difficult.

Students also rated the complexity in navigation of each portion of the selected WebQuest. The largest differences between the two groups were found in their ratings for introduction ($\underline{m}$ = 1.81 for elementary; m = 1.00 for secondary) and process or procedure ($\underline{m}$ = 2.38 for elementary; 1.63 for secondary) portions of the web site. The majority of elementary teachers rated the introduction section as about right, whereas the majority of secondary teachers rated it as easy. More elementary teachers found the process (procedures in carrying out the WebQuest tasks) as difficult than did the secondary teachers.

The authors worked together to perform a qualitative analysis of comments that students wrote in response to rating one common web site's information density and complexity in navigation. We developed categories that emerged from the data and calculated frequencies for comments within categories. To briefly describe these derived categories, aspects of cognitive load included brevity, appropriateness of load or overload; positive or negative aspects of linking; difficulty or ease of internal navigation; presence of choices, usability; time; and interactivity. Elementary teachers had more comments, more complete comments and more specific observations than did the secondary teachers, as for example, commenting on the color and font size of the web site. That elementary teachers had more detailed comments may not be surprising, considering that they had been trained in teaching of reading and have had more extensive background in working with special education students than did the secondary teachers.

Contribution & Interest to NARST

This study uses a web-based inquiry instructional model that is now a part of science teacher education, the WebQuest, as a vehicle to further understanding of criteria teachers need for critical evaluation and selection of web-based resources for science teaching. That web-based inquiry lessons are now part of science teacher preparation is seen in Abruscato's introductory discovery methods book for elementary and middle grades (2000), where he explains that science WebQuests provide "real reasons" to use computers to investigate real world contexts involving science. Abruscato describes WebQuests as teacher-prepared discovery projects for students that involves giving learners practice in use of science process skills (e.g. observing, classifying, predicting; use integrated science process skills (e.g. interpreting data, formulating hypotheses); and support of the approach to lesson planning known as the Learning Cycle.

However, to our knowledge, there is little systematic research to inform teacher educators, who now have the need to prepare teachers to critically evaluate and select web-based resources for their students to use in web-based inquiry learning. We believe that our work links research on cognitive load with research on the need to prepare

teachers to critically evaluate and select web sites for student use in web-based inquiry lessons and projects. This is a useful way to prepare preservice teachers to make effective determinations regarding the selection and incorporation of web-based science materials in their classroom instruction. In addition, our present study extends our prior work on developing criteria for teachers to use in evaluating the credibility and cognitive load aspects of web sites ,and in selecting web-based resources for developmentally appropriate instruction.

References

Abruscato, J. (2001). Teaching children science: Discovery methods for the elementary and middle grades. Boston: Allyn and Bacon.

Bannert (2002). Managing cognitive load – recent trends in cognitive load theory. *Learning and Instruction 12(1)*, 139-146.

Chandler, P., Sweller, J. (1991). *Cognitive load theory and the format of instruction. Cognition and Instruction, 8*, 293-332.

Dodge, B. J. (1995) Some thoughts about WebQuests [Online]. Available: http://edWeb.sdsu.edu/courses/edtec596/about_Webquests.html.

Iding, M. (2000). Is seeing believing? Features of effective multimedia for learning science. *International Journal of Instructional Media, 27(4)*, 403-415.

Iding, M. K., Auernheimer, B., Crosby, M. E., & Klemm, E. B. (2002, May). Users' Confidence Levels and Strategies for Determining Web Site Veracity. *Proceedings of The WWW 2002: The Eleventh International World WideWeb Conference.*

Iding, M. K., Crosby, M. E., Auernheimer, B., & Klemm, E. B. (2002). Critical evaluation skills for web-based information: "Lies, damned lies" and web-based information. *Proceedings of the ED-MEDIA 2002: World Conference on Educational Multimedia, Hypermedia & Telecommunications.*

Iding, M., Landsman, R., & Nguyen, T. (in press). Critical evaluation of scientific websites by high school students. *WCCE (World Conference on Computers in Education) 2001 Conference Proceedings*. The Netherlands: Kluwer Academic Publishers.

Iding. M. & Klemm, E. B. (2002, July). Teachers critically evaluate scientific information on the World Wide Web. Paper presented at the 19th World Congress on Reading. Edinburgh, Scotland.

Kirshner (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning, *Learning and Instruction 12(1)*, 1-10.

Klemm, E. B., Iding, M., & Speitel, T. (2001). Do scientists and teachers agree on the credibility of media information sources? *International Journal of Instructional Media 28(1)*, 83-91.

Lewin, L. (2001). Using the Internet to Strengthen Curriculum. Alexandria, VA: Association for Supervision and Curriculum Development.

Mayer, R. E. (1999, April). When multimedia works: Designing multimedia for meaningful learning. Paper presented at the annual meeting of the American Educational Research Association.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12(3)*, 185-233.

Valcke (2002). Cognitive load: updating the theory? *Learning and Instruction 12(1)*, 147-154.

Van Merrienboer, J.J.G., Schuurman J.G., de Croock, M.B.M., & Paas, F.G.W.C. (2002) Redirecting learners' attention during training: effects on cognitive load, transfer test performance and training efficiency *Learning and Instruction 12(1)*, 147-154.

Ward, M., and Sweller, J. (1990). Structuring effective worked examples. *Cognition and Instruction, 7(1)*, 1-39.

ED067774

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Cognitive Load Criteria for Critical Evaluation and Selection of Web-Based Resources for Science Teaching

Author(s): Klemm, E. Barbara; Iding, Marie K; and Martha E. Crosby

Corporate Source: NA

Publication Date: 2003

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

1

Level 1

☑

Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.

The sample sticker shown below will be affixed to all Level 2A documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2A

Level 2A

☐

Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only

The sample sticker shown below will be affixed to all Level 2B documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2B

Level 2B

☐

Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: E. Barbara Klemm	Printed Name/Position/Title: Professor	
Organization/Address: College of Education, University of Hawaii	Telephone: 808-956-3823	FAX: 808-956-9905
	E-Mail Address: klemm@hawaii.edu	Date: 4/23/03